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ABSTRACT

This student module on steel erection safety is one of 50 modules concerned with job safety and health. This module identifies typical jobsite hazards encountered by steel erectors, as well as providing safe job procedures for general and specific construction activities. Following the introduction, 11 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., List requirements for temporary flooring). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

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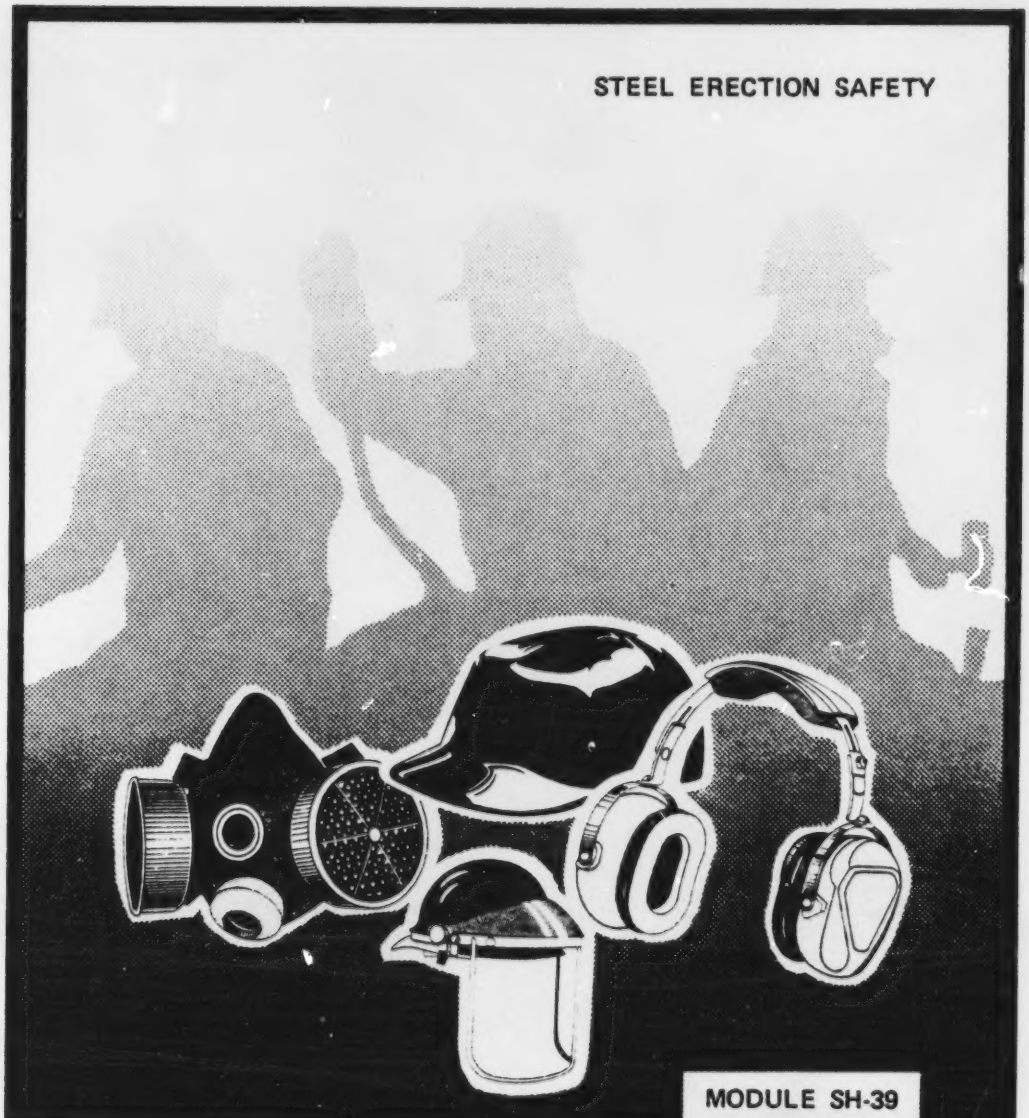
SAFETY AND HEALTH

STEEL ERECTION SAFETY



MODULE SH-39

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INTRODUCTION

Work-related accidents have caused the construction industry to focus upon the improvement of working conditions and accident prevention programs, especially in the area of structural steel erection. The potential for serious injury or death exists for steel erectors as a direct result of the types of operations performed and tools and equipment used in this skilled trade.

The contractor's most valuable asset is the worker. Skilled workers must not only work swiftly and accurately, but also safely, if a project is to be completed on time and within bid costs. Accidents cost in time, materials, and increased insurance premiums, all of which are built into bid contracts. Therefore, safety is important if a contractor expects to make a profit and retain the skilled workers necessary to a successful contracting organization.

This module identifies typical jobsite hazards encountered by steel erectors, as well as providing safe job procedures for general and specific construction activities. It will provide basic information relative to tools, equipment, and materials used in contemporary steel construction of buildings, signs, and other steel structures.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. State the general safety considerations for lifting and hoisting equipment, including "manufacturer's capacity rating" and "safety factor." (Page 3)
2. Give three safety precautions or good practices concerning the use of air tools. (Page 11)
3. Describe the general safety features of some impact tools. (Page 13)
4. Discuss types of fasteners used in steel erection and safe job procedures for the use of each type. (Page 14)

5. Name the three basic categories of welding and discuss hazards associated with welding. (Page 16)
6. List the main hazards associated with drilling and reaming, "plumbing up," and connecting when erecting steel. (Page 26)
7. Explain the reason for additional safety problems when erecting steel during plant operations. (Page 29)
8. List the general requirements for personal protective equipment in steel erection operations, including mention of four operations that require eye protection. (Page 31)
9. Describe the dangers of working under or near live electrical wires. (Page 35)
10. Name two external forces which affect lateral bracing. (Page 36)
11. List requirements for temporary flooring. (Page 37)

OBJECTIVE 1: State the general safety considerations for lifting and hoisting equipment, including "manufacturer's capacity rating" and "safety factor."

Hoisting equipment and apparatus are used extensively for transporting tools and building materials from one level to another on steel erection jobsites. Such hoisting equipment may consist of electrical, pneumatic, or hand-operated hoists, or powered-stationary or mobile cranes. The nature of the loads carried (heavy steel beams and concrete forms) and the heights involved make steel erection jobsites even more hazardous than other construction jobs. Thus, certain precautions should be routinely followed in the use of heavy hoisting equipment.

CRANES

Types of cranes most typically found on steel erection jobsites are hammerhead tower cranes, overhead and gantry cranes, and crawler, locomotive, or truck cranes. Each type of crane has its own specific set of safe operating procedures. However, a few general safety guidelines can be applied to the operation of most cranes. All crane operators must be trained according to the specifications listed in OSHA standards. (The training requirements for crane operators are listed in 29 CFR 1910.179 and 1910.180.)

The most basic requirement for crane safety is that the employer must comply with the crane manufacturer's specifications and limitations. Rated-load capacities, recommended operating speeds, and special hazard warnings or instructions should be visibly posted on the equipment to which they apply, as well as being visible to the equipment operator while the crane is in use. Because cranes are carefully designed and engineered for specific uses, no modifications or additions to the crane should be made without the written permission of the crane manufacturer.

The term "rated load" refers to the weight of the load that may safely be lifted by a crane. The rated load must be plainly marked on each side of

the crane, and on each hoisting unit when more than one hoisting unit exists. The rated-load capacity must also be identifiable to the crane operator while the crane is in use. The weight of the load to be lifted will be known by the trained and experienced operator. The weight of blocks, hooks, and other devices must be considered when the total weight of a load is figured. The crane should never be loaded beyond its rated capacity, except by trained and authorized personnel and then for testing purposes only. The capacity to safely lift a load decreases as the length of the boom increases, a job is added, or the radius of operation is changed. The crane should be kept level, with weight evenly distributed. Unbalanced positioning will place excessive force upon the boom.

Centrifugal force can pose a hazard when cranes are making a lift. As a load is moved and swung into place, centrifugal force may cause the load to swing farther than expected unless the operator moves the load into place very slowly. A tagline is recommended where centrifugal force or wind may be a problem. (See Figure 1.)

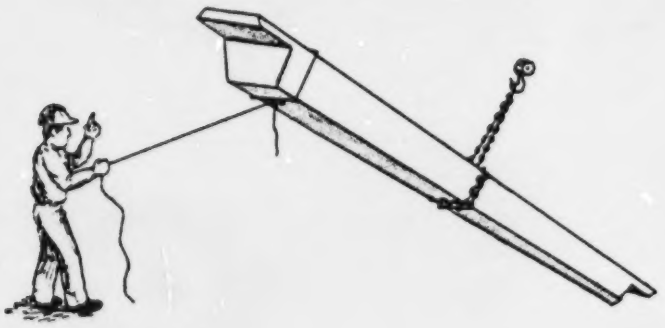

Figure 1. Taglines are recommended where centrifugal force is a problem.

Three types of crane inspections should be performed: daily, annual, and special.

The crane should be inspected prior to use on a daily basis, or at the beginning of each shift. This inspection should include a check to be sure that the machine is properly lubricated. The brake and clutch as well as each control should be operated to be sure that each functions properly. If possible, the load brake and limit switch should be checked at capacity or near capacity load. Each part of the crane used in lifting or moving a load should be visually inspected. This includes but should not be limited to

sheaves, drums, hooks, jib, and so forth. The boom or tower should be visually inspected for deformity, twist, straightness, cracks or abrasion. Likewise, wire rope must be inspected for wear, kinks, or any other conditions which may impair performance. Wire rope is discussed in a later section of this module. The daily inspection is made to ensure that the equipment is in immediate safe operational condition. Should any deficiency be found, the crane should be removed from service until it has been repaired.

All hoisting equipment should be inspected annually by a competent person or an agency recognized by the U.S. Department of Labor. The employer must keep a log of the dates of inspection and the results of inspections for each piece of equipment.

The third type of inspection is the special inspection and should be made whenever the crane is exposed to abnormal stress such as whipping, snapping, overload, or other possible damage.

MATERIAL AND PERSONNEL HOISTS

Material and personnel hoists can be either inside or outside hoists. (Hoists can carry either material or personnel, but not both at the same time.) Inside material hoistways should be enclosed with heavy wire screening throughout their height. An external or outside hoistway must be enclosed with heavy wire screening and firmly footed or secured to the structure which it serves. Personnel hoists must conform to ANSI A17.1-1965, "Safety Requirements for Personnel Hoists."

Hoistway enclosures must be constructed so that when subjected to horizontal pressure of 100 lb, the enclosure will not deflect more than 1" and the clearance between the car and the hoistway enclosure is not less than 3/4" except for the side used for loading and unloading. Doors on hoistways should not be less than six feet high. If a solid door is used, there must be a vision panel. Landing doors should lock mechanically so that they cannot be opened from the landing side, except on the lowest level. Only the person inside the car should be able to open the car. Hook-and-eye hardware is not to be used as a door-locking device on hoistways.

Bells or lights on a hoisting system help to determine exactly where a hoist platform is and in what direction it is traveling. When a bell system is used, the bell wire should be well-protected and used every time the hoist is operated. A bell or light system is preferable to a whistle system, (which may be confused with other construction sounds) or to a hand signal system, (which requires the engineer and signalman to be in visual contact). The following set of signals is suggested by the Associated General Contractors of America:

- 1 bell or light - Stop.
- 2 bells or lights - Raise.
- 3 bells or lights - Lower.
- 4 bells or lights - Lower Slowly.

The signals should be clearly posted. The hoist rope can be marked to indicate each landing, and should be marked with paint and not rags or other material that can catch and snag.

An emergency stop switch should be located in the car and clearly marked "STOP." Each car intended as a personnel hoist should be marked with a capacity and data plate.

Hoists, especially ropes and engines used to draw the hoist, should be inspected frequently. Preventive maintenance will disclose hazardous conditions before an accident occurs.

WIRE AND FIBER ROPE

Wire rope and fiber rope are used extensively in construction for moving and securing material. Each type of rope has an application based upon its physical characteristics. Fiber rope may be made of natural or synthetic fiber. Natural fiber rope includes manila, hemp, sisal, jute, as well as cotton, asbestos, and other specialized materials. Synthetic rope may be made of nylon, polyester, or polypropylene, and these materials have the advantage of higher tensile strength and resistance to rot.

Wire rope may be single strand wire or consist of a number of wires wound in lays around a core. The size, number, arrangement of wires and strands, and the types of core determine the use of a specific type of

rope. The greater the number of wires in a strand, and the greater the number of strands, the more flexibility there is in a rope. Flexibility is a primary consideration in crane or derrick hoisting ropes.

Safe load limits for ropes are determined in experimental situations. These "ideal conditions" are not often the same as those encountered in an actual work site; therefore, a safety factor is assigned to compensate for the rigors of everyday wear. Assigning a numbered safety factor to a piece of equipment or material is a way of relating the breaking strength of a material to the maximum permissible stress when it is in use.

For example, if a material hoist platform has a breaking strength of 4000 pounds (under ideal test conditions) and is designed with a safety factor of five, the platform should carry no more than 1/5th of 4000 pounds or 800 pounds. The maximum safe load would be 800 pounds.

The safety factor for wire ropes is found by dividing the breaking strength (rated by the manufacturer or determined by testing) by the total of the weights to be lifted (static load). Recommended minimum safety factors are six for haulage ropes, overhead cranes, and derricks; seven for small electric and air hoists; and eight for hot ladle cranes.

All wire rope used in lifting and hoisting should be checked daily. There are three basic causes of wire rope deterioration: abrasion or wear, corrosion, or rope fatigue caused by bending, twisting, or crushing. If the core shows through more than one pair of strands, or if there is more than one broken wire in one strand, the wire should be removed from service. Spliced wire must never be used in critical lifting. Evidence of corrosion, twisting, or other mechanical damage, as well as excessive wear on outside wires of rope are indications that a wire is no longer serviceable. Any defective rope should be replaced immediately with the same size and type of rope.

Wire rope that is used as part of a hoisting apparatus is part of the lifting machine and should be kept lubricated. Each time the rope bends or wraps around a sheave or straightens from a slack position, the wire strands rub or slide against each other. Lubrication will prevent excessive wear, corrosion, and deterioration of fiber core rope. Rusty rope is dangerous,

since there is no known way of determining the depth to which the rust penetrates, and the amount of strength which remains.

SLINGS AND CHAINS

Slings are lifting accessories made of chain, metal and mesh, or rope. They distribute weight more equally than a rope and hook alone, and allow for greater control of a load as it is moved. The safety and efficiency of a sling is dependent upon the proper selection of the sling for its purpose. The type of lifting, the attachment of rope or chain to the fitting, and the maintenance and inspection of the sling affect the safety of the sling, also.

The angle of the sling affects the working load limit. Strains build up rapidly at angles greater than 60°. Angles less than 45° should be avoided.

Space blocks and corner padding added to loads can reduce the wear on wire rope or slings used to hoist structural steel or other loads. (See Figure 2.)

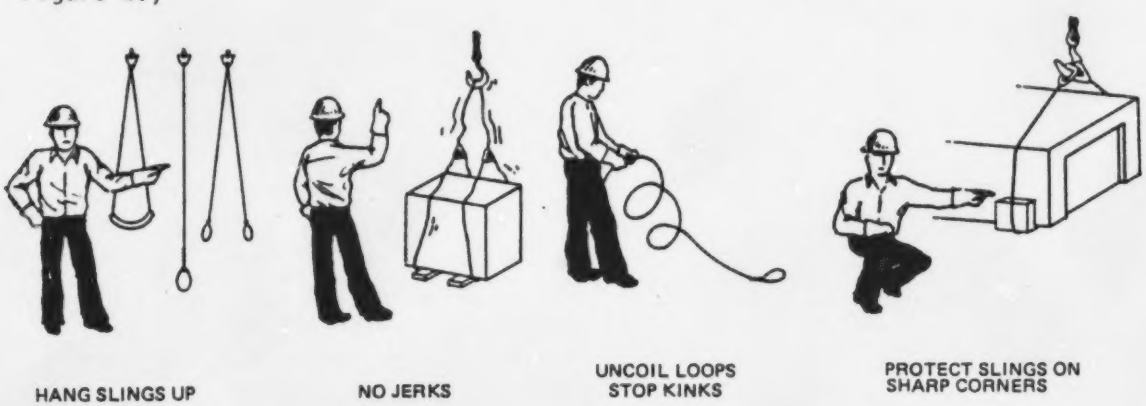

Figure 2. Correct methods for handling and storing slings.

Slings should be hung carefully when not in use, not carelessly left lying about where they can be damaged. Slings should be inspected carefully for wear and damage and removed from service if fittings are loose.

A chain used as part of a hoisting apparatus is no stronger than its weakest link. Therefore, chains should be inspected link by link on a frequent basis and discarded when signs of wear or damage appear. A chain

should be discarded also when it shows evidence of having been stretched. Small checks or cracks in individual links, elongations of links, and binding of links indicate stretching. Bent or deformed links, thin areas caused by rubbing, or any crushing of links are also indications that the chain should be taken from service and replaced. Exposure to excessive heat or electricity can also cause a chain to fail under load conditions.

A chain should never be welded or spliced by inserting a bolt between the links. Permanent identification tags are attached to chain slings by the manufacturer and should never be removed. When a chain is used for lifting, the load should be taken up slowly to avoid overstressing the links of the chain. Only clean attachments (rings, shackles, couplings, and end-links) appropriate for the particular type of chain in use should be employed in hoisting. No open hook should be used with a bucket, cage, or skip when material is being hoisted over workers. Each hook should have a latch or other device to prevent the link from slipping and allowing the load to fall. Whenever the throat opening of any hook exceeds 15 percent of its original dimension, it should be replaced. Hooks that are twisted, stretched or cracked should be replaced, also. Hooks must never be welded, nor should attempts be made to straighten or bend deformed areas back to shape. Hooks are made of metal that is heat treated to create strength to withstand stresses; this strength is lost when the physical shape of the hook is altered intentionally or by accident.

The use of a thimble in an eye splice distributes more equally stresses on a splice, and thus reduces the wear on the rope. Clips and fasteners allow lifting equipment to be attached to ropes. It is important to use only the type of fastener designated for a particular rope, or strength will be lost. Zinc-poured sockets work well in straight-tension, but they are not as fatigue-resistant as swaged sockets.

Bolts, rivets, and drift pins should be stored and transported in containers provided for that purpose. These and other small items should be hoisted in pails rather than carried by hand while moving between floors. Additionally, the good housekeeping practice of picking up fallen bolts, rivets, and pins will ensure no one loses footing as the result of someone else's carelessness.

One general rule applies to all types of hoisting. Loads should never be suspended over workers, no matter how safe the hoisting equipment is considered to be.

ACTIVITY 1:*

1. Name two factors that make steel erection jobsites even more hazardous than ordinary construction jobs.
   a. _____
   b. _____
2. Explain what manufacturer's rating capacity means.
   _____
   _____
3. Name three types of inspections typically performed on cranes, derricks, and hoists.
   a. _____
   b. _____
   c. _____
4. Name three basic causes of wire rope failure.
   a. _____
   b. _____
   c. _____
5. Explain why a chain should be inspected frequently; what conditions should be observed.
   _____
   _____
6. Explain what a safety factor of five means.
   _____
   _____

*Answers to Activities begin on Page 39.

OBJECTIVE 2: Give three safety precautions or good practices concerning the use of air tools.

Pneumatic tools, which utilize compressed air, are essential equipment on many steel erection sites. Compressed air is regarded by many workers as "just air," and thus they believe that it is harmless. Compressed air is air driven at a high velocity, and like the air traveling at high speeds in tornadoes and hurricanes, compressed air can be deadly. However, compressed-air tools, known as pneumatic tools, can be safe and reliable if they are handled properly.

Compressed air can be supplied to tools by a cylinder or by a motor-driven compressor. The air hoses between the source of the air and the tool can present a tripping or stumbling hazard. Air hoses can be protected by laying them between two planks, by building a runway over the hoses, or (preferably, where it is practical) by suspending air hoses over work areas and aisles. If hoses are suspended, they must be properly supported.

The source of compressed air should always be cut off before the air hose is disconnected from the airline; pressure from the air line should be bled off or slowly released before disconnecting. These precautions are important because a loose air hose under pressure makes a very dangerous whip. To prevent pneumatic tools from becoming accidentally disconnected, tools must be secured to hoses by some positive means. The coupling of hoses can be secured by an annealed wire fastened through holes in the coupling itself. A better method involves a length of chain attached to each hose by means of a safety snap.

Hoses with an inside diameter of more than 1/2" should have a safety device at the source of supply or at the branch line to reduce pressure in the case of a hose failure. The condition of tools and hoses should be continuously checked for wear and damage. All connections and couplings should be checked for tightness. Air hoses should never be used in place of ropes, chains or handles as a means of hoisting or lowering a tool. The manufac-

turer's safe operating pressure must never be exceeded for pipes, hoses, valves, couplings, or other fittings.

Horseplay with compressed air apparatus must be strictly forbidden. A blast of air at 40 pounds per square inch can rupture an eardrum at a distance of four inches, or more seriously, can cause a fatal brain hemorrhage. As little as 12 pounds per square inch can pop an eyeball from its socket; compressed air can also enter the bloodstream even through skin and a layer of clothing. Compressed air tools should never be looked into or pointed at any person. Compressed air should not be used for cleaning purposes. When used properly, compressed air is a useful means for getting the job done; improperly or carelessly used, it is very dangerous.

ACTIVITY 2:

1. Mark each statement TRUE or FALSE.

   ___ a. Compressed air is simply air and so is harmless except in the case of a few freak accidents.

   ___ b. The source of compressed air should be cut off before the air hose is disconnected from the airline and the airline pressure should be bled off because an unattached air hose with pressure in it can whip about dangerously.

   ___ c. Hoses less than 1/2" inside diameter should have a safety device at the source of supply or branch line to reduce pressure in case of a hose failure.

2. Name three ways air hoses can be protected and kept from becoming a tripping hazard.

   a. _____

   b. _____

   c. _____

OBJECTIVE 3: Describe the general safety features of some impact tools.

There are several basic types of impact tools generally found on steel erection construction sites: powder-actuated (stud gun), reciprocating piston (riveting guns and jackhammers), and rotary (impact wrenches and reamers).

Two basic safety features that must be found on pneumatic impact tools are - an automatic closing valve actuated by a trigger that is located inside the handle to prevent accidental operation, and a retaining device that holds the tool in place so that it cannot be accidentally fired from the barrel. Only flush-fitting pins should be used to secure the socket of an impact wrench. If nails or wire are used, severe injury could result to hands or body.

Heavy rubber grips on jackhammers reduce vibration and jolting from the hammer to the operator. Properly prepared and maintained steel drills are necessary for the equipment to operate safely and efficiently. Firm footing is necessary when using heavy or unwieldy tools.

Some impact tools generate noise levels in excess of 85 dB. The worker can be protected by isolating the operation, substituting quieter methods or tools, or providing hearing protection for all exposed workers.

Powder-actuated tools drive a stud or fastener with an explosive charge. The guidelines for safe use of powder-actuated tools are detailed in OSHA Standard 1910.243(d). Only properly trained and qualified operators should be allowed to operate these tools. Many areas require trained, tested, and licensed operators only. Training can be provided through many sources: union local, apprentice training programs, or manufacturer's representatives. Upon successful completion of a basic training course, an examination is written and sent to the Powder-Actuated Tool Manufacturer's Institute, who will certify and issue an operator's card to those who successfully complete a training course.

No matter what type of impact tool is used, if there is any question about the safe procedure to follow, the worker should always bring the matter to the attention of his supervisor. If the supervisor is unable to solve the problem, the manufacturer should be contacted for further information.

ACTIVITY 3:

Name three safety concerns related to the use of impact tools.

1. _____
2. _____
3. _____

OBJECTIVE 4: Discuss types of fasteners used in steel erection and safe job procedures for the use of each type.

Bolts and rivets are the two major types of fasteners used in contemporary steel erection of buildings and bridges.

Bolts are used with increasing frequency in the field of assembly of structural steel. These bolts are high-tensile machine bolts or structural rib bolts, and they eliminate many of the old hazards of hot riveting. Such bolts must never be "thrown" (put into place) with an air hammer; by both shape and material they are not designed to be thrown.

Bolts, washers, and drift pins should be stored and carried in containers. They must never be left lying on beams and scaffolds. Anything left on walking or working surfaces can cause a worker to trip, stumble, or fall to serious injury or death. Workers should not carry objects in their hands when climbing ladders; tools should be carried in a basket or in the worker's tool belt in the frogs (or loops), and not between a belt and the body. Bolts and other similar items may be carried in a bolt bucket or bag, and transported by means of a tag line.

Wrenches used for tightening bolts must be the proper size and in good condition; wrenches with worn or sprung jaws should never be used because a slipping wrench could throw a worker off balance. Firm footing is important when bolting up. The use of a length of pipe on a wrench handle to gain leverage should not be allowed because of the danger of slippage.

When an impact wrench is being used, care must be taken to see that the air lines do not create a tripping hazard. The air lines should also be protected and secured from falling, as the weight of the hoses themselves can pull a worker to the ground if care is not exercised. Impact wrenches must have a locking device for retaining the socket, and should not be used unless the socket is properly attached.

When bolts or drift pins are knocked out, some means should be provided to keep them from falling. Bolts or pins can be caught in a bolt basket or a bucket with a wooden bottom. One of the most serious hazards steel erectors face is falling objects of all sizes; workers are sometimes struck by falling objects, or such objects create a tripping hazard.

Another method of fastening structural members is through the use of rivets. The riveting crew consists of a heater, bucker-up, catcher, and driver. The person who acts as heater heats rivets throughout the day, while other members of the crew rotate jobs. Each rivet heater must have a pail of water on hand at all times for emergency use, and to put out the fire in the forge when leaving the job. Ashes should be disposed of carefully.

To keep rivets from flying off and striking someone, a proper shield must be used when backing out rivets or knocking off rivet heads. There should be enough approved containers to hold all loose materials. Workers should never stand in front of a rivet buster.

Rivet snaps should always be wired into guns. Air hammers should have a safety wire installed on the snap and handle; the wire attached to the handle should not be less than No. 9 (B & S wire gage) and annealed wire on the snap should not be less than No. 14.

Workers must never use fingers to check or align holes in plates or other materials; fingers can be amputated or crushed easily by shifting materials. Gloves are advisable under many circumstances.

All tools used should be inspected frequently, and removed from service when defects are discovered. The air hammer must not be placed where it can be kicked or slip accidentally. Safe work practices when riveting include wearing proper clothing, keeping a firm footing, and using personal protective equipment. Noise levels can be excessive on the steel erection job; if so, hearing protectors should be used. Safety goggles and glasses must be worn while riveting. A safety belt must always be worn and the worker must be tied to the safety line. Head protection and steel-toed footwear are essential on steel erection jobsites.

ACTIVITY 4:

1. Name five hazards that may be encountered when bolting or riveting.
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
2. Name personal protective equipment that must be used when one is bolting or riveting.
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____

OBJECTIVE 5: Name three basic categories of welding and discuss the hazards associated with welding.

Simple steel connections may be accomplished by welding, as well as by using rivets, bolts, or pins. Although the American Welding Society has

identified over 80 different types of welding and allied processes in commercial use, the three basic types of welding used in steel erection are oxyacetylene welding, resistance welding, and arc welding.

OXYACETYLENE WELDING

Oxyacetylene welding is a gas welding process that uses oxygen and acetylene gas. (Regulations for its use are covered under 1926.350, Subpart J - Welding and Cutting.) Oxygen is provided as a compressed gas in steel cylinders. Although not flammable in itself, oxygen supports combustion; materials burn (oxidize) more rapidly in oxygen. Acetylene is a highly flammable gas and is most typically supplied (as a compressed gas) in cylinders. As a flammable gas, acetylene ignites easily and burns with a higher flame temperature than any other gas (approximatley 6000°F). Because acetylene is very hazardous, safe handling techniques are especially important.

Cylinders of compressed gas must be stored at least 20 feet from all combustible materials. This includes the storage of oxygen and acetylene. (See Figure 3.) The cylinders must also be stored away from sparks, open flames, and excessive heat. When the cylinders are not in use, the valve protection caps must be in place. The cylinders must be legibly marked to identify their contents and must be chained or otherwise secured to prevent toppling. When a cylinder is empty - (1) it should be marked MT, (2) the valves should be closed, and (3) the valve cap should be replaced. Cylinders that are not marked as empty should be handled as if they were full, since containers under partial pressure can explode.

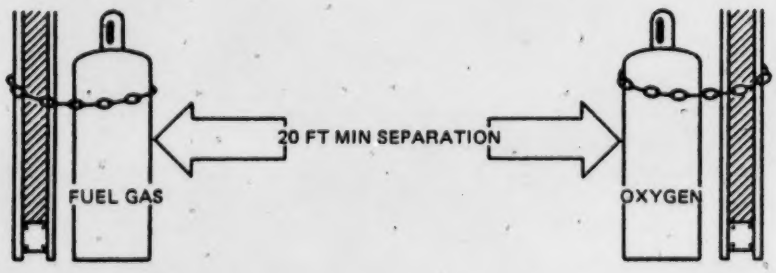

Figure 3. Cylinders of compressed gas must be stored at least 20 feet from all combustible materials.

The regulator that mixes the gases in proper proportions must be handled carefully at all times. A non-sparking end wrench of the proper size must be used when attaching the regulator to the cylinders. Pipe wrenches or pliers must not be used for attaching the regulator, and cylinders with hand wheels must not be opened or closed with hammers or wrenches.

"Creeping" of a regulator is indicated by a gradual increase in pressure after the torch valves are closed. If a regulator "creeps," it should be removed from service, and repaired at once.

Compressed gas cylinders must never be moved with an electromagnet. Whenever gas cylinders must be handled by crane or derrick, they should be carried in a cradle or on a platform; a spring should not be used. Care should be taken that gas cylinders are not dropped.

Cylinders are difficult to move because of their size and shape. They should be protected from scraping and other damage, and never dragged. Cylinders weighing 40 pounds or more must be transported on a hand or motorized truck. All hose connections should be checked for proper threading. Standard hose connections are threaded right-hand for oxygen and left-hand for acetylene or other fuel gas. This helps prevent accidental switching of hoses. The hoses should be color coded to avoid accidental mixup: green for oxygen and red for acetylene.

Any hose showing leaks, burrs, or worn places must be replaced or repaired. Hoses should never be repaired with tape; it will not hold. Hoses can be tested for leaks under normal operating pressure, by immersing the hose in water, or by coating it with soapy water.

Only bronze or brass fittings must be used on compressed gas cylinders. Copper fittings must never be used on acetylene, since, under certain conditions, copper and acetylene can form an explosive mixture. Grease, oil, or other similar substances must never be used on or near the torch or regulator. Oil and grease burn furiously in the presence of oxygen.

Before a welding torch is lighted, the hoses supplying gases must first be purged. The valve on the acetylene cylinder should be opened not more than one and one-half turns, with three-fourths of a turn preferable. The acetylene torch valve should be opened one-fourth turn; the acetylene should

be adjusted to working pressure (15 psig or 30 psia) with the gas regulator screw. The acetylene torch valve is then closed.

The same procedure is repeated with the oxygen cylinder and torch. The oxygen cylinder is slowly opened all the way; then the oxygen torch is opened one-half turn. The oxygen is adjusted with the gas regulator screw, and the oxygen torch valve is turned off.

The actual lighting of the torch is accomplished by reopening the acetylene torch valve one-fourth turn and lighting the gas with a friction lighter (matches must never be used). The oxygen valve is opened one-fourth turn, and the flame is adjusted.

The proper way to shut off the torch is to close the torch valves - acetylene first, then oxygen. The cylinder valves are closed in the same order - acetylene first, then oxygen. Both torch valves are then opened to release the pressure. The regulator adjusting handle is shut off until no spring tension can be felt. Finally, the torch valves are closed. This procedure should be followed whenever operations are shut down for the day or the job completed. Gas welding setups must be broken down before transporting from one location to another. By carefully following this procedure, the possibility of a regulator fire when the oxygen cylinder is opened is diminished and acetylene and oxygen leaks are prevented.

RESISTANCE WELDING

Resistance welding is a metal joining process in which the heat of electrical resistance seals metal to metal. Spot welds are made by applying heat and pressure on one point, usually on overlapped parts; seam welds are a series of spot welds, spaced closely to form a seam. Welding current is sometimes furnished by the stored-energy type of equipment, in which energy is stored in capacitors or a combination transformer-reactor. When the energy is discharged, a weld is formed. Low primary current and high voltage are involved and care must be taken to avoid electrical accidents.

All electrical installations should conform to applicable codes and regulations, and be performed only by qualified and trained personnel. A fused safety switch or circuit breaker must be close to any welding machine being worked on in order to prevent unathorized or accidental activation.

Portable machines must have adequate guards to prevent accidental contact. All equipment must be thoroughly inspected, especially cables, which are particularly subject to abuse.

Electrodes used in resistance welding (made of copper or copper alloy) are not consumed or deposited on the work as with arc welding. Electrodes and electrode holders should be water-cooled to reduce the chance of heat burns to the operator.

ARC WELDING

Arc welding joins metals by heating with an electric arc or arcs, with or without pressure and with or without filler metals. It is accomplished with a carbon or metallic electrode, solid or flux-cored wire (gas shielded metal arc welding), or a covered wire (shielded metal arc). The welding machine can be either a.c. or d.c. supplied.

Because most arc welding is done with metal-coated electrodes consumed as welding progresses, the welder should be protected against exposure to welding fumes from the electrode, the metal worked on and any coatings on the metal. Fumes from many metals containing cadmium, copper, nickel and zinc are capable of producing metal fume fever. The symptoms of metal fume fever are flu-like (chills, fever, muscle and joint pain, nausea), including a metallic taste in the mouth and a dryness of the nose and mouth. These symptoms generally last less than 24 hours and a temporary immunity follows. Welding on galvanized metal can cause metal fume fever, as can welding in confined spaces. Proper ventilation and respiratory protection can minimize welding health hazards. Although not inclusive, the following list of metals describes some of the possible exposures of which welders should be aware.

- Aluminum - In welding and cutting operations, aluminum is a major component of metals and filler metals. The inhalation of aluminum dust or its compounds, including aluminum oxide fumes, is not known to have any effects on man.
- Antimony - Antimony is used as an alloying metal in many specialty metals. Antimony and its compounds irritate the skin and mucous membranes. Skin contact with antimony can result in inflammation of the hair follicles. A greater infection may develop that produces scars. Symptoms of excessive exposure to airborne antimony

are a metallic taste in the mouth, vomiting, loss of appetite, and general stomach distress.

- Arsenic - Arsenic may be encountered in welding and cutting operations as a component of various alloys. It is used as a hardening agent. Welding or cutting on metals that are painted with arsenic compounds can also be hazardous. Arsenic is a poison that accumulates in the body. It is deposited in many bodily tissues, especially the liver and kidneys. Because the effects of arsenic may not appear for weeks, months, or even years after exposure, workers should be protected from exposure. Because serious skin irritation results from contact with rubber in the presence of arsenic, respirators should not be made of rubber. Exposure to excessive concentrations of arsenic compounds produces inflammation of mucous membrane surfaces and an irritation of exposed skin. Common symptoms in exposed workers include skin irritation, irritation of the nasal passages, laryngitis, and mild irritation of the lungs and eyes.

- Asbestos - Asbestos is found in the coatings of some welding rods. Long-term exposure to high concentrations of asbestos fibers causes asbestosis, a disease of the lung. Under normal circumstances of welding with coated rods containing asbestos, hazardous concentrations are not produced. However, the welder should be sure that good ventilation is in operation during welding processes in which such rods are used.

- Beryllium - Beryllium is sometimes used as an alloying element with copper and other base metals. Acute exposure to high concentrations of beryllium can result in chemical pneumonia and even death. Long-term exposure can result in shortness of breath, chronic cough, and significant weight loss, accompanied by fatigue and general weakness.

- Cadmium - Cadmium is used frequently as a rust-preventive coating on steel and also as an alloying element. Acute exposures to high concentrations of cadmium fumes can produce severe lung irritation, chest pains, and possible death from pulmonary edema (fluid in the lungs). Long-term exposure to low levels of cadmium in air can result in emphysema (a disease affecting the ability of the lung to absorb oxygen) and can damage the kidneys.

- Carbon Monoxide - Carbon monoxide is a gas usually formed by the incomplete combustion of various fuels. Welding and cutting may produce significant amounts of carbon monoxide. In addition, welding operations that use carbon dioxide as the inert gas shield may produce hazardous concentrations of carbon monoxide in poorly ventilated areas. This is caused by a "breakdown" of the shielding gas. Carbon monoxide is odorless and colorless and cannot be detected. Common symptoms of overexposure include pounding of the heart, a dull headache, flashes before the eyes, dizziness, ringing in the ears, and nausea. If allowed to accumulate, carbon monoxide may produce unconsciousness and death in a matter of minutes.

- Chromium - Chromium is the primary alloying agent in stainless steel. Chromium compounds are strong oxidizing agents and are extremely toxic and irritating to the skin, eyes, and mucous membranes. Although welding under normal operating conditions would not be expected to produce hazardous concentrations of chromium compounds, welding of stainless steel should be carried out in well-ventilated areas.
- Chlorinated Hydrocarbon Solvents - Various chlorinated hydrocarbons are used in degreasing or other cleaning operations. The vapors of these solvents are a concern in welding and cutting because the heat and ultraviolet radiation from the arc will decompose the vapors and form highly toxic and irritating phosgene gas. (See Phosgene.)
- Cobalt - Cobalt appears as an alloying agent in high-strength, high-temperature alloys. Inhalation of cobalt fumes can cause shortness of breath and coughing. In most cases, symptoms disappear after exposure ends.
- Fluorides - Fluoride compounds are found in the coatings of several types of fluxes used in welding. Exposure to these fluxes may irritate the eyes, nose, and throat. Repeated exposure to high concentrations of fluorides in air over a long period may cause pulmonary edema (fluid in the lungs) and bone damage. Exposure to fluoride dusts and fumes has also produced skin rashes.
- Iron Oxide - Iron is the principal alloying element in steel manufacture. During the welding process, iron oxide fumes arise from both the base metal and the electrode. The primary acute effect of this exposure is irritation of nasal passages, throat, and lungs. Although long-term exposure to iron oxide fumes may result in iron pigmentation of the lungs, most authorities agree that these iron deposits in the lung are not dangerous.
- Lead - The welding and cutting of lead-bearing alloys or metals whose surfaces have been painted with lead-based paint can generate lead oxide fumes. Inhalation and ingestion of lead oxide fumes and other lead compounds will cause lead poisoning. Symptoms include metallic taste in the mouth, loss of appetite, nausea, abdominal cramps, and insomnia. In time, anemia and a general weakness, chiefly in the muscles of the wrists, develop.
- Magnesium - Magnesium and magnesium-aluminum alloys, both found as alloys in steel, are used in the manufacture of structural parts for airplanes, and in tool making. Welding and cutting on magnesium-containing metals produces magnesium oxide fumes, and exposure to these fumes can irritate the eyes, nose, and throat, and may result in fume fever.
- Manganese - Manganese is a constituent of many arc welding electrodes. The welding process produces manganese dioxide fumes. In most cases, the concentrations generated are not hazardous. Nevertheless, cases of manganese poisoning have been reported.

Symptoms of manganism, a severely crippling disease that results from excessive exposure, are weakness, instability, difficulty in walking, and monotonous and intermittent speech.

- Mercury - Mercury compounds are used to coat metals to prevent rust or to inhibit foliage growth (marine plants). Under the intense heat of the arc or gas flame, mercury vapors will be produced. Exposure to these vapors may produce stomach pain, diarrhea, kidney damage, or respiratory failure. Long-term exposure may produce tumors, emotional instability, and hearing damage.
- Nitrogen Oxides - The intense energy produced by the arc can create nitrogen oxides. The most significant form is nitrogen dioxide. This gas is mildly irritating to the eyes, nose, and upper respiratory tract at relatively low concentrations. It is hard to detect, and dangerous concentrations can be inhaled without any discomfort, even to the point when injury to the lungs results.
- Ozone - Ozone is a gas that is produced by the ultraviolet radiation in the air in the vicinity of arc welding and cutting operations. Ozone is very irritating to all mucous membranes, with excessive exposure producing pulmonary edema. Other effects of exposure to ozone include headache, chest pain, and dryness in the respiratory tract.
- Phosgene - Phosgene is formed by the decomposition of chlorinated hydrocarbon solvents by ultraviolet radiation. It reacts with moisture in the lungs to produce hydrogen chloride, which in turn destroys lung tissue, and the resulting pulmonary edema can cause death. For this reason, any use of chlorinated solvents should be well away from welding operations or any operations in which ultraviolet radiation or intense heat is generated.
- Phosphine - Phosphine or hydrogen phosphide can be produced when steel that is coated with phosphate rustproofing is welded. Excessive concentrations of this gas are irritating to eyes, nose, and skin. Acute effects, besides irritation, include headache, dizziness, and pulmonary irritation. Chronic exposure may result in disturbances of sight and speech.

There are specific requirements concerning ventilation and the use of respirators when welding or cutting is done on stainless steel, lead, zinc, or cadmium; metals coated with materials such as paint that may contain lead or mercury; and on fluxes or other materials containing fluorides. These requirements are summarized in the following table.

TABLE 1. VENTILATION AND RESPIRATOR EQUIPMENT FOR WELDING AND CUTTING OPERATIONS.

Welding or Cutting on Materials Containing or Coated with	Location of Operation		
	Confined Spaces	Indoors	Outdoors
Lead	A or B	A	C
Zinc	A or B	A	
Cadmium*	A or B	A or B	C
Beryllium*	A and B	A and B	A and B
Mercury*	A or B	A or B	C
Fluorine*	A or B		
Stainless steels	A	A	A

*Unless atmospheric tests under the most adverse conditions have established that the workers' exposure are within acceptable concentrations defined by 1910.1000.

A = Mechanical load exhaust ventilation by means of either hoods or booths with sufficient air flow to maintain a velocity, away from worker, of at least 100 linear feet per minute.
B = NIOSH-approved supplied-air respirator, or equivalent.
C = NIOSH-approved respiratory protective equipment, or equivalent.

Safety and health information is often printed on tags, boxes, and containers of filler metals, fusible granular materials, welding fluxes, and other welding supplies. Information on toxicity, symptoms of overexposure, first aid procedures, and control of employee exposure may be provided.

A very common hazard in welding is flash burns. These burns can be caused by ultraviolet and infrared radiation, as well as intense visible light.

Ultraviolet radiation is generated by the electric arc in the welding process. This type of radiation can cause skin burns similar to sunburn, as well as burns to the eyes. Special eye protection must be worn to protect against eye burns. Ultraviolet radiation can also increase skin irritation in the presence of industrial chemicals such as coal tar and cresol products.

Infrared radiation is produced by an electric arc and other flame-cutting equipment. It may heat the skin and the surface below. In some situations, this heating can progress to thermal burns, but generally infrared radiation is not dangerous. Welders can be protected from the effects of ultraviolet and infrared radiation with a welder's helmet (or glasses) and protective clothing.

Intense visible light can cause retinal damage in the eye. For this reason, at no time should any welding or cutting process be viewed without eye protection. Eye protection is discussed in a later section of this module.

ACTIVITY 5:

Choose the best answer.

1. Oxygen -
   a. is highly flammable.
   b. supports combustion (materials burn rapidly in oxygen).
2. Acetylene -
   a. is highly flammable.
   b. supports combustion (materials burn rapidly in acetylene).
3. Regulator "creep" is a -
   a. normal occurrence in functioning regulators.
   b. malfunction that calls for the regulator to be taken out of service.
4. Oxygen hoses are color-coded -
   a. green.
   b. red.
5. Exposure to certain metal fumes can range in effect from -
   a. metal fume fever to respiratory irritation.
   b. no effect at all to death from acute severe exposures.

6. Phosgene is formed by -
   a. the decomposition of chlorinated hydrocarbon solvents.
   b. phosphate rustproofing.
7. Burns to the eyes are associated with:
   a. gas welding.
   b. electric arc welding.
8. Metal fumes from welding operations are most likely to build up to dangersous levels -
   a. in confined spaces.
   b. indoors.

OBJECTIVE 6: List the main hazards associated with drilling and reaming operations, "plumbing up," and connecting when erecting steel.

The use of portable reamer drills in erecting steel requires that attention be given to safe and proper operating procedures. Care must be taken so that neither clothing, hair, jewelry, watches, rings, nor gloves are caught in revolving parts of equipment.

High-cycle (180 Hz a.c.) equipment has the disadvantage of continuing to rotate after power has been switched off. This can be overcome through the use of dynamic braking. Dynamic braking sends direct current across one of the phases of the motor winding to stop the motion. The high-speed rotor generates and circulates a current in its winding that causes the stored energy of acceleration to be transferred into heat, and thus to provide the braking effect. The spindle will then generally stop in three or four revolutions. The high-cycle equipment has the advantage of being lighter in weight per unit of power than equipment supplied by ordinary 60-cycle equipment. The high-cycle equipment will also stall before developing a high overload torque. Electric drills and reamers should be grounded through the

use of three-wire cord serviced by a properly installed and maintained electrical source.

Reamer drill bits must be maintained in good condition, free from burrs or nicks at dull edges. Should any of these conditions be detected, the bit must be disposed of or reground by qualified personnel. The bits must never be struck with a hard object or tossed or thrown; they are made of very hard steel and are easily damaged by abuse. Chips may fly from the bit or object.

The proper size bit should be selected for a job; an undersized bit may crack or break, whereas a bit that is too large may seize up. The drill bit must be kept straight when drilling or reaming. Attempting to speed up drilling or reaming by applying excessive pressure may cause the bit to freeze in the hole, so only sufficient pressure should be used. Chips and shavings should be removed with a brush or other suitable equipment; the hands and fingers must never be used as steel and metal chips and shavings are extremely sharp. All work should be firmly secured by clamps, bolts or other approved means. Should the bit bind up in work which is not secured, the work may spin free, striking the worker or persons in the vicinity. The worker must not attempt to secure the work with his hands, or by standing on it.

The two-handled reamer drill is heavy and requires two operators of approximately the same height and physical ability. When lifting the machine, the workers should keep their backs straight, and lift with the legs, bending at the knees, to avoid causing injury to their backs. Improper lifting techniques are a leading cause of lost-time accidents in the construction industry. Every worker, no matter how strong, should be aware of the proper way to lift the equipment and materials used on the jobsite.

The use of a two-handled type reamer drill in a corner should be avoided unless the supervisor is consulted first. If permission is granted to remove a handle, the remaining handle should be supported against a solid piece of steel to keep the unit from moving. Wherever practical, a hand grip attachment should be used on the back of the tool.

Guy wires used in "plumbing up" (setting up vertically) should be fastened in such a manner that the bolters, riveters, or welders have access to

the connection points. If adequate anchorage is not available, suitable deadmen (such as a truck or other heavy equipment) must be used. Ropes and cables used in plumbing up should be inspected to ensure that there are no breaks, twists, or abrasions that cause weakening of the strands, and eventual rope failure.

When cable clips are installed, the correct size and number must be used. The clip farthest from the eye should be tightened first. After all clips are tightened, they should be inspected at least once more after being placed, as the rope diameter becomes smaller under the stress of stretching. Clips should be checked frequently.

After the hooks or lashings used for plumbing up are attached securely, the turnbuckle may be installed and adjusted. Once the turnbuckle is tightened, a device should be used to prevent its unwinding. The turnbuckle should be wired or attached to a solid object to prevent unscrewing under strain.

Guys should not be removed without first getting the permission of the job superintendent. Guys should never be fastened to a railroad truck where they might be cut off by railcars. All guys should be guarded against other moving objects.

A set of directional signals similar to those used by crane operators should be established before starting to plumb up a structure.

When connectors are working together, one should give the signal. The connectors should keep their eyes on the steel as it approaches. The beam should be bolted so that it cannot roll and, before being cut loose, the bolting should be checked to be sure that this cannot happen.

Beams should be connected with a minimum of two bolts at each end. If only one bolt is used, it should be fastened through the top hole and tightened with a hand wrench. Any deformed piece should be returned to the ground to be properly dressed.

To walk safely on steel with beam studs, workers should straddle a beam and walk on the bottom flange wherever it is possible to do so. Pants legs should be tucked in or tied and nothing should be carried when moving on steel.

Hands and fingers must be kept away from connections to avoid their being crushed.

Columns, trusses, and beams must never be cut until all fasteners have been installed. Before lifting falls are unhitched from columns, the nuts should be drawn down tightly on the anchor bolts, or temporary guy lines should be attached.

Workers should stay on the side of the column where the swinging steel cannot hurt them. When work is being done above vertical steel reinforcing rods, the exposed ends should be covered or bent down.

When rain, high wind, or other weather which may pose a hazard to workers threatens, erection operations should be suspended until safe conditions permit.

ACTIVITY 6:

1. Name four hazards related to the use of reamer drills.
   a. _____
   b. _____
   c. _____
   d. _____
2. Mark each of these statements TRUE or FALSE.
   ___ a. Beam should be connected by one bolt at each end.
   ___ b. Before being cut loose, the beam should be bolted so that it cannot roll.

OBJECTIVE 7: Explain the reason for additional safety problems when erecting steel during plant operations.

Steel erection during plant operations poses special safety concerns. There is usually considerable activity and congestion due to normal plant operations, as well as to the presence of other contractors and their

materials. The operating plant supervisor should be responsible for all phases of work being done in the plant. The steel erection foreman should be responsible for obtaining clearance from the operating plant supervisor.

Each contractor is responsible for the health and safety of his or her respective employees. If another contractor on a site is working with materials, chemicals, or equipment in a manner that endangers the steel erector's employees, then the steel erector contractor is responsible. Each contractor must be responsible for the safety of his or her workers.

Work areas must be clearly defined, and all utilities (gas, electric, and so on), and other potentially hazardous contacts must be identified and marked. All existing plant regulations must be obeyed. Access should be restricted to the contractor; operating personnel and others should gain access only by permission of the superintendent or foreman.

Operating cranes should not be used without permission of the operating superintendent. When work is being performed on or near an operating crane, rail stops should be placed between the steel worker and the operating crane. If this is not possible, a safety operator in the crane cab should be posted to protect the steel worker. Flasher lights are recommended to denote the work area and warn the crane operator.

ACTIVITY 7:

1. What conditions may pose special safety concerns when erecting steel during plant operations?
   a. _____
   b. _____
   c. _____
2. Who is responsible for jobsite safety? _____
   _____

OBJECTIVE 8: List the general requirements for personal protective equipment in steel erection operations; including mention of four such operations that require the use of eye protection.

Most serious injuries sustained by steel erectors can be prevented, or the severity of the injury can be reduced if the worker uses appropriate personal protective equipment. Helmets, safety-toed shoes, protective eyewear, and gloves are needed most often; in all cases, the equipment worn should match the job.

In areas where there is a possibility of head injury from impact, falling or flying objects, or electrical shock or burns, the worker must wear protective headgear. This headgear must meet or exceed specifications contained in the American National Standards Institute (ANSI) Z89.1-1969, Safety Requirements for Industrial Head Protection. Additionally, helmets for employees exposed to high-voltage electrical shock and burns must meet specs contained in ANSI Z89.2-1971. Metal hard hats are not allowed for electricians or other personnel who might contact electrical conductors. Generally, helmets of fiberglass or durable plastic material are used by those working under electrical hazard conditions. The electrical test for this type of hat states that the headgear will withstand, without breakdown, an application of 2200 V for one minute between any point on the crown and inside suspension.

Standard specifications for hard hats require that, under test conditions, the headgear must withstand the impact of an 8-pound iron ball dropped from a height of five feet without breaking, denting, or cracking.

Not all hard hats provide adequate protection on the jobsite. Bump caps protect only against minor bumps, since the close fitting suspension of these caps makes them almost useless against hard blows. The absence of lacing suspension in a regular hard hat allows the transmission of any heavy blow directly to the wearer's skull. Thus, all safety hats should be suited

to the hazards of the worksite. All hats should be inspected for flaws and cracks. Intentionally drilling holes in the shell of the hard hat seriously compromises the safety factor provided by the headgear.

Headgear has been classified in two types: full brimmed, and brimless with peak. These types are broken down into four classes:

Class A - Limited-voltage resistance for general service.

Class B - High-voltage resistance.

Class C - No voltage protection (metallic helmets).

Class D - Limited protection for firefighters service.

All helmets that meet ANSI Standard Z89.1 or Z89.2 are identified on the inside of the helmet shell with the manufacturer's name, ANSI designation, and class. Plastic helmets withstand impact better than metallic helmets, but because the metallic helmet is lighter in weight, it is sometimes preferred by the worker. Metallic helmets must never be worn in an electrical hazard area or in the presence of corrosive materials.

Safety-toed boots and shoes provide protection against crushing injuries to the foot, as well as providing safe footing when working on steel. Some soles on safety footwear are puncture resistant; leather uppers prevent hot welding material from burning through.

OSHA requires that a safety-toe shoe be used for work that requires the handling of heavy material. These shoes have a reinforced steel toe cap capable of withstanding heavy blows and great pressures. For construction, the steel toe cap must be capable of sustaining a static load of 2500 lb or the impact of a 75-lb weight dropped 18 inches with a clearance of 16/32". Safety shoes are divided into three classifications under ANSI Z41.1, Men's Safety Toe Footwear. (Safety specs are the same for women's footwear.)

Metatarsal (or overfoot) guards, when worn in addition to safety shoes, protect the foot from heavier impact. Heavy-gage, flanged, and corrugated metal footguards protect the foot from the toe to the ankles.

Workers must be provided with eye and face protection whenever machines or operations present potential for eye injury from physical, chemical or radiation hazards. A steel worker requires eye protection when welding, chipping, grinding, riveting, knocking off rivet heads, using any hand or power tools, and when exposed to chemical hazards. The eye and face

protection must comply with ANSI Z87.1-1979, "Practices for Occupational and Education Eye and Face Protection." The protection equipment must be kept clean and in good repair. Any defects, such as scratching or pitting on lenses, seriously compromise the protection afforded by the eyewear.

The proper shade for welding lenses must be selected. The shade number must be at least that stated on Table 2, although shades more dense than those listed may be used to suit the worker's needs.

Workers whose assignment requires them to be exposed to laser beams (such as in steel-cutting operations) must have suitable laser safety goggles that protect the wearer for the specific wavelength of laser used, and are of the optical density adequate for the energy involved.

Excessive noise levels can cause permanent hearing loss. Any noise exceeding 85 dBA (decibels on the "A" scale) is recognized as hazardous to human hearing. Ideally, a noise should be reduced at its source. In many instances, however, it is impossible to reduce or isolate sound at its source, so the worker must be provided with hearing protectors. Hearing protectors fall into two main groups - the plug or insert type, and the cup or muff type. Ear protective devices inserted into the ear must be fitted or determined individually by competent persons. Insert-style hearing

TABLE 2. PROPER SHADES FOR WELDING LENSES.

Welding Operation	Shade Number
Shielded metal-arc welding 1/16-, 3/32-, 1/8-, 5/32-inch diameter electrodes	10
Gas-shielded arc welding (nonferrous) 1/16-, 3/32-, 1/8-, 1/8-, 5/32-inch diameter electrodes	11
Gas-shielded arc welding (ferrous) 1/16-, 3/32-, 1/8-, 5/32-inch diameter electrodes	12
Shielded metal-arc welding 3/16-, 7/32-, 1/4-inch diameter electrodes	12
Shielded metal-arc welding 5-16-, 3/8-inch diameter electrodes	14
Atomic hydrogen welding	10–14
Carbon-arc welding	14
Soldering	2
Torch brazing	3 or 4
Light cutting, up to 1 inch	3 or 4
Medium cutting, 1 inch to 6 inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to 1/8-inch	4 or 5
Gas welding (medium), 1/8-inch to 1/2-inch	5 or 6
Gas welding (heavy), over 1/2-inch	6 or 8

protectors help prevent hot sparks from welding operations from entering the ear canal and causing serious burns in the ear canal. Plain cotton is not an acceptable protective device. Further, no matter how good a hearing protector is, it is of no value unless it is used.

Gloves may be necessary to protect against friction, chemical burns, or sharp edges, or for some operations, such as welding. For welding, a leather glove extending well over the wrist is needed. Hand guards are designed to reduce the likelihood of cuts and lacerations from sharp edges of sheet metal or steel; these gloves have padded leather palms and fingers and allow for maximum hand flexibility. Gloves must not be worn around operating machinery; they can become entangled and draw the hand or arm into the moving parts of the machinery.

ACTIVITY 8:

1. Name at least four operations in steel erection that require eye protection.
   a. _____
   b. _____
   c. _____
   d. _____
2. (Fill in the blank.)
   Any noise exceeding ____ dBA can cause hearing loss.
3. Name the two major types of hearing protectors.
   a. _____
   b. _____
4. List four types of personal protective equipment used in steel erection.
   a. _____
   b. _____
   c. _____
   d. _____

OBJECTIVE 9: Describe the dangers of working under or near live electrical wires.

The dangers of working under or near live electrical wires are many; therefore, workers in such situations follow closely a number of safety rules.

The practice of workers riding loads, hooks or headache balls should be strictly forbidden; wind, sway, fatigue, mechanical or human failure could result in contact with live electrical wiring, causing injury or death.

No worker should be exposed to live electrical hazard, unless the employee is protected against electrical exposure by grounding, guarding, or de-energization of the circuit.

Every electrical tool and cord used on the jobsite should be inspected. Any tool or cord not checked can be a death threat to the worker, since even a small electrical shock could cause a fall by startling the worker.

The use of alcohol or other drugs must be avoided on all jobs. Concentration is especially crucial to avoid injury or death on jobs at heights and around mechanized equipment.

Minimum electrical clearances must be observed whenever any tool, machinery or equipment may contact energized conductors or establish a direct path to the ground. These clearances apply in any direction, vertical or horizontal.

Crane boom movement must be limited by special equipment (such as crossarms) if cranes are operated in an area of potential contact. Warning signs legible at 12 feet must be posted. Whenever any work is to be performed within 10 feet of a high-voltage line, the person operating the high-voltage line must be notified as well as the supervisor, so that all safety precautions can be taken before work proceeds.

ACTIVITY 9:

1. Name two dangers of working under or near live electrical wires.
   a. _____
   b. _____
2. Name four precautions which may prevent accidental electrical contact.
   a. _____
   b. _____
   c. _____
   d. _____

OBJECTIVE 10: Name the two external forces that affect lateral bracing.

Lateral (on the side) bracing of structures is necessary to allow for two external forces: (vertical) weight and (horizontal) windload. If adequate bracing is not provided, the structure could collapse, since exterior walls are sometimes exposed to forces beyond their designed capacity. Table 3 shows how great the force of wind can be.

TABLE 3. EXTERIOR WALLS ARE SOMETIMES EXPOSED TO GREAT FORCE FROM WIND.

Miles per Hour	Force per Square Foot - in lb	Miles per Hour	Force per Square Foot - in lb
1	0.005	20	1.969
2	0.020	25	3.075
3	0.044	30	4.429
4	0.079	35	6.027
5	0.123	40	7.873
6	0.711	45	9.963
7	0.241	50	12.30

8	0.315	55	14.9
9	0.400	60	17.71
10	0.492	65	20.85
12	0.708	70	24.1
14	0.964	75	27.7
15	1.107	80	31.49
16	1.25	100	49.2
18	1.55		

Masonry walls should follow structural erection so that lateral stability will be provided; building codes require that the proper bracing and support be provided while the walls are being erected. OSHA regulations state, "Masonry walls shall be temporarily shored and braced until the design level strength is reached due to wind or other forces."

ACTIVITY 10:

Name the two external forces that affect lateral bracing.

1. _____
2. _____

OBJECTIVE 11: List requirements for temporary flooring.

As the erection of the steel progresses, permanent flooring should be installed. There should never be more than four floors (or 48 feet) of unfinished bolting or welding above the foundation or uppermost permanent floor. The erection floor should be solidly decked or planked over except for hoist openings. The planking or decking should be capable of carrying a working load of 50 pounds per square foot. Openings through which a worker may fall must be covered with planks of sufficient strength to support a 200-lb person and any load which might be transported across the opening. Alternatively, the opening must be guarded on all sides by rails, including midrails and toeboards. Any runway or scaffold built around or over a floor opening must have standard rails and toeboards. Until permanent protection is installed, the temporary protection must not be removed.

Planks used in temporary flooring must not be less than 2" thick, full-sized undressed, as well as straight grained and free of serious defects. They should be laid closely together, fastened to the framework, and secured to prevent slippage and displacement, especially in winds. The bearing ends should overlap by a minimum of 12". When metal decking is used in place of planks, it should be laid straight and tight, and also fastened to prevent movement. Care must be taken in wet or other adverse weather conditions, as wood and metal decking can become slippery.

Where temporary flooring is impracticable, as in mall construction and other structures where flooring is not required or where overhead crane operations do not permit temporary flooring, safety belts and lifelines must be used by the worker. Safety belts and lifelines are used where a worker might be exposed to falls of 15 feet or more (EXCEPT when exposed to tying or reinforcing). The steel, six-foot anchor end of the safety belt or lifeline must be attached at all times to the worker (at not lower than waist level) and at a distance of not more than six feet horizontally. The lifelines must be attached to a sturdy member of the structure or to securely rigged lines using a positive descent-control device; the use of nylon rope is recommended. Rigging must be provided if duties require horizontal movement, so that the lifeline will slide along with the worker.

ACTIVITY 11:

List four requirements for wood floor planks.

1. _____
2. _____
3. _____
4. _____

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ANSWERS TO ACTIVITIES

ACTIVITY 1

1. a. Heights.
   b. Heavy loads that are lifted.
2. Manufacturer's rating capacity is the maximum safe load which may be lifted by a crane or hoist. This rating must be posted and clearly visible.
3. a. Daily inspection, or at the beginning of each shift, to see if:
      - Machine is properly lubricated.
      - Brake and clutch work well.
      - Load brake and limit switch are functioning properly.
      - Each part of crane used in lifting or moving a load is working well.
   b. Inspection by Department of Labor inspectors.
   c. Special inspection, whenever machinery is exposed to abnormal stress.
4. Any three.

   Abrasion or wear; corrosion; rope fatigue caused by bending, twisting, or crushing; "bird caging"; broken wires in a strand; core

showing through more than one pair of strands; and lack of lubrication.

5. Since a chain which is used as part of a hoisting apparatus is no stronger than its weakest link, chains should be inspected frequently. Conditions to be checked for include: stretching, elongation of links, bent or deformed links, cracks or checks in links, and thin areas caused by rubbing.
6. A safety factor of five means that the safe maximum load of the mechanism is one-fifth its breaking strength. Thus, if a hoist platform has a breaking strength of 4000 pounds and a safety factor of five, the maximum safe load would be 800 pounds.

ACTIVITY 2

1. a. False.
   b. True.
   c. False.
2. a. Laying hose between planks.
   b. Building runway over hoses.
   c. Suspending air hoses over runways.

ACTIVITY 3

(Any three.)

1. Pneumatic impact tools should have an automatic closing valve actuated by a trigger, and a retaining device to hold the tool in place so it cannot be accidentally fired.
2. Jackhammers should have rubber grips to reduce vibration; steel drills must be properly prepared and maintained.
3. Firm footing is necessary for safe operation.
4. Only properly trained and qualified operators should use powder-actuated tools.

ACTIVITY 4

1. (Any five)
   a. Rivets may fly and strike someone.
   b. Fingers may be crushed easily by materials shifting when holes are being aligned.

c. Air hammers may slip.

d. Excessive noise levels may damage hearing.

e. Eye damage may result if safety goggles are not worn.

f. Impact tools may cause injury.

g. Air hoses can become detached and flip a worker to the ground.

h. A slipping wrench could throw a worker off balance.

i. There is danger of falling when "bolting up."

2. (Any five)

a. Safety goggles.

b. Safety belt.

c. Helmet.

d. Steel-toed shoes.

e. Hearing protection.

ACTIVITY 5

1. b.
2. a.
3. b.
4. a.
5. b.
6. a.
7. b.
8. a.

ACTIVITY 6

1. (Any four)

a. Clothing and jewelry can become entangled.

b. High-cycle equipment continues to rotate after being switched off.

c. Reamer drill bits can chip and chips fly from the bit.

d. Chips and shavings can cause cuts.

e. The bit may bind up in the work, causing the work to spin free and strike the worker.

f. Heavy equipment may damage one's back if lifted incorrectly.

2. a. False.

b. True.

ACTIVITY 7

1. (Any three)
   a. Activity and congestion, thus more danger from inattention and carelessness.
   b. Hazards from workers or materials on other projects on the work-site.
   c. Utilities may be contacted by accident.
   d. Unauthorized personnel may cause accidents.
2. Each contractor is responsible for the safety of his own employees.

ACTIVITY 8

1. (Any four)
   a. Welding.
   b. Chipping.
   c. Grinding.
   d. Riveting.
   e. Knocking off rivet heads.
   f. Hammering.
   g. Compressed-air work.
   h. Overhead work.
2. 85 dBA.
3. a. Plug or insert type.
   b. Cup or muff type.
4. (Any four)
   a. Safety helmets (hard hats, not bump cap).
   b. Safety (steel-toed) boots and shoes; with or without metatarsal guards.
   c. Safety goggles and glasses.
   d. Welding lenses of the specific shade needed.
   e. Gloves with or without hand guards.
   f. Ear protectors or plugs.

ACTIVITY 9

1. (Any two)
   a. Accidental contact of personnel with live electrical wires.

b. Lack of, or deficient grounding of circuits.

c. Cranes or other machinery may contact live wires or other energized conductors of electricity.

d. Shock causing a fall.

2. (Any four)

a. Tools and cords should be inspected to ensure safe operating conditions.

b. Workers should not ride loads, hooks, or headache balls.

c. Live electrical circuits should be properly grounded, guarded, or de-energized.

d. Minimum electrical clearances should be observed.

e. Crane boom movement must be limited by special equipment if cranes are operated near live wires.

f. Limited access and posting of hazardous locations.

ACTIVITY 10

1. Weight (vertical).
2. Wind load (horizontal).

ACTIVITY 11

(Any four)

1. Planks used in temporary flooring must be at least 2" thick, full-sized, undressed.
2. Planks must be straight grained and free of serious defects.
3. Planks must be laid closely together.
4. Planks should be fastened to the framework.
5. The bearing ends should overlap by a minimum of 12".